

Postoperative Outcomes of Volar Plate Fixation in Cases of Scaphoid Deformity or Nonunion: A Case Series

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Abstract

Background Fractures through the waist of scaphoid are a common injury, resulting in deformity or nonunion. Recently, a locking plate has been shown to fix deformity or nonunion of scaphoid, with limited observation of functional postoperative outcomes.

Objectives We present a case series of 16 patients, with the disabilities of the arm, shoulder, and hand (DASH) score evaluation in primary fixation of scaphoid fractures with humpback deformity ($n = 11$) and revision open reduction internal fixation (ORIF) for nonunion ($n = 5$), using the Medartis TriLock 1.5 scaphoid plate and bone grafting.

Patients and Methods DASH scores were obtained preoperatively and postoperatively at 3, 6, and 12 (if required) months. Patient demographics, smoking status, employment type, and grip strengths were recorded.

Results Thirteen patients attended follow-up. Union was clinically and radiologically assessed with 13 achieving union. The mean preoperative DASH score was 34.0 ($n = 16$) and at treatment completion (discharge or DNA) was 11.5 ($n = 13$), with mean reduction of 18.5 ($p = 0.03$). At treatment completion, mean reduction in DASH score of revision ORIF was 13.7 ($p = 0.27$; $n = 4$), compared with 20.7 ($p < 0.01$; $n = 9$) in primary fixation with plate.

Conclusions Deformity correction, reduction in DASH score, and rate of union make the plate system useful in the management of scaphoid fractures with humpback deformity and revision for nonunion.

Level of Evidence This is a Level IV study.

Keywords

- ▶ scaphoid fracture
- ▶ humpback deformity
- ▶ nonunion
- ▶ plate fixation
- ▶ DASH score

Scaphoid fractures are a common hand injury in adults, accounting for 60% of carpal fractures, with an incidence of 12.4 in 100,000 each year in the United Kingdom.^{1,2} Most of these fractures are sustained in low-energy injuries, particularly a fall on an outstretched hand, while others result from high-energy trauma, including road-traffic incidents.³

Fractures through the waist of the scaphoid are the most frequently encountered (70% of cases) and there is a signifi-

cant incidence of delayed union and nonunion (5–25%).⁴ Conservative management with cast immobilization is indicated for undisplaced, stable fractures, while operative management is favored in displaced fractures due to the risk of mal or nonunion and avascular necrosis of the scaphoid.⁴

Historically the fixation method of choice has been the headless compression screw. Bone grafting is a useful adjunct in cases of bone loss, atrophic nonunions, or deformity.⁵

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However, there are inherent disadvantages with this fixation technique such as the difficulty in positioning the screw optimally and the lack of rotational stability.⁶ Although the rate of nonunion of 5–25% postfixation has a multitude of contributory factors,⁷ we feel that some of these shortcomings are primarily attributable to the failure of the headless compression screws to provide adequate rotational stability in the presence of a structural bone graft, especially to correct a “humpback” deformity, due to reduced compression force of the screw over time.^{6,8}

The advent of volar anatomical locking plates provides another fixation method within the fairly limited armamentarium of the scaphoid surgeon. Recent studies on volar plate fixation have shown acceptable outcomes.⁹ The utility of the scaphoid locking plates has been most pronounced in cases of nonunions with a significant humpback deformity and for revision fixation.^{9,10}

We present our case series of 16 consecutive patients demonstrating successful and reproducible volar plate fixation in a combination of patients with humpback deformity and nonunion following primary fixation with headless compression screw. This was conducted to answer the primary question whether this technique improves rate of union and postoperative function. We also observed patient demographics and measures including grip strength, employment type, smoking status, and complications.

Patients and Methods

Study Design and Statistics

Sixteen consecutive cases of scaphoid nonunion were treated using volar plate fixation in our center over a period of 28 months. These were a selection of those with a nonunion with a humpback deformity and nonunion following primary fixation with headless compression screws. Nonunion has been defined as failure of fracture site union, with ongoing symptoms 6 months following primary injury.¹¹ The disabilities of the arm, shoulder, and hand (DASH) score was utilized prefixation and postfixation as a measure of functional outcome, taking into account both significance of the data and the minimal clinically important difference of 15 points, as defined by different studies in the official guidance of using the DASH score.^{12,13} Out of the 16 patients, 3 did not attend any follow-up and were not considered for statistical analysis. Among the 13 patients, 5 had undergone primary surgery using headless compression screws. Revision with plate fixation and distal radius grafting was indicated for symptomatic nonunions. One patient from this was lost to follow-up.

An assessment of grip strength was conducted with the operated wrist compared with the nonoperated wrist in 11 patients. Smoking status of patients was factored in to assess outcomes using reduction in DASH scores postoperatively at completion of treatment. The mean number of months from surgery to measuring grip strengths was 4 months ($n = 11$). The sample was also retrospectively divided into two equal groups of eight, one having operation within 12 months of primary injury and the other over 12 months after primary injury. Final DASH scores were available for seven cases in the former group

and six cases in the latter group, which were then compared. Complications were recorded too. Written consent was obtained for publication of clinical photographs and imaging.

Surgical Technique

Patients underwent fixation for nonunion under general anesthesia, with or without nerve block (supraclavicular or peripheral) with limb tourniquet. The Linscheid maneuver was used to correct the dorsal intercalated segment instability (DISI) deformity by inserting a 1.6-mm Kirschner's wire (K-wire) dorsally through the distal radius to the lunate with the wrist in a flexed position.¹⁴ This allowed estimation of the humpback deformity (►Fig. 1) on taking down the mal or nonunion.

A volar approach to the scaphoid was utilized with the Garcia-Elias ligament splitting capsulotomy (►Fig. 2) used for the potential V-Y plasty closure of the capsule and



Fig. 1 X-ray imaging demonstrating humpback deformity of scaphoid.



Fig. 2 Garcia-Elias splitting capsulotomy.

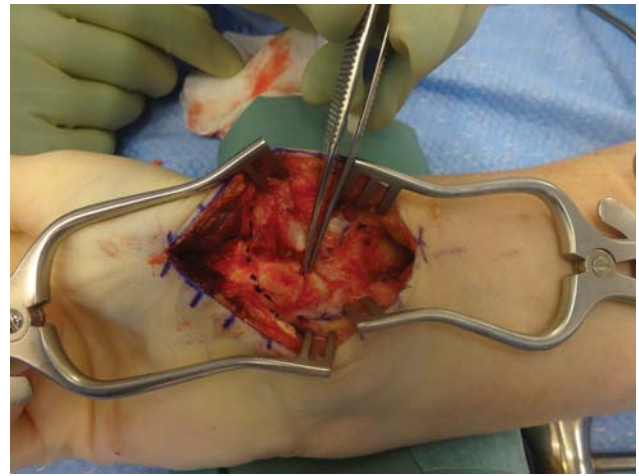


Fig. 4 Measuring of the fracture gap.

ligament complex.¹⁵ The fibrous tissue within the nonunion site was removed leaving a dorsal bridge to maintain the alignment of the two fragments. Two 1.25-mm K-wires were inserted into the proximal and distal poles allowing joysticking and achieving control of the scaphoid (►**Fig. 3**). The proximal and distal medullary surfaces were fenestrated with a 1.25-mm K-wire. Bleeding from the proximal fragment was noted, as a predictor of vascularity, which is thought to be associated with a higher bone healing capacity score and a lower duration to union.^{16,17}

The fracture gap was measured (►**Fig. 4**) and a corresponding area on the volar radius was grafted premarking with a 1.6-mm K-wire and osteotome. The graft was inserted into the nonunion site and impacted with a bone punch. The Medartis TriLock 1.5 mm 6-hole locking scaphoid plate was applied to the volar surface of the scaphoid, along with a cortical screw to both the proximal and distal poles (►**Fig. 5**). The dorsal lunate K-wire was removed. The wrist was then taken through a full range of flexion and extension to ensure that the plate did not catch against the volar rim of the radius. The remaining four screws were locking. The scaphoid was screened to ensure the screws were not protruding. Closure

was achieved with braided absorbable sutures. We removed the most proximal screw hole for two early cases to avoid impingement; however, having gained experience with this plate, we no longer consider this to be necessary. Our surgical technique and methods applied were similar to the current literature.¹⁸

Postoperative Care and Follow-up Routine

Immediately postoperatively patients were immobilized in a back slab. Wound review occurred 2 days postoperatively and conversion to a full cast when the swelling allowed. The full cast was changed to a custom-made thermoplastic splint at 5 weeks postoperatively with range of movement exercises commencing from the splint. The splint was then gradually weaned, aiming to discard this by 8 weeks. Clinical review occurred at 6 weeks, 3 months and 6 months, with patients completing DASH scores at 3 months and beyond. If there were clinical concerns of union, patients were invited to review at 9 and/or 12 months. Union was defined clinically as resolution of pain and radiographically as consolidation of the fracture/graft site on plain scaphoid view X-ray scans. Where union was still in question, computed tomography



Fig. 3 Two Kirschner's wires inserted to control scaphoid.



Fig. 5 Postfixation with the volar locking plate.

(CT) scan was performed. CT scanning was not conducted if X-ray findings suggested union, the patient was asymptomatic or the postoperative DASH scores were low.

Results

Descriptive Data

A total of 16 patients underwent this procedure, all being male. The age range of patients was observed to be 17 to 41 years and the median age was 23 years.

Rate of Union

A 100% rate of union was observed overall in the patients that attended follow-up ($n = 13$).

DASH Scores

DASH scores of all patients at different time intervals is illustrated in ►Table 1. Using Wilcoxon's matched pair testing, the attending 13 patients demonstrated a statistically significant mean reduction of DASH scores of 28.5 at completion of treatment ($p = 0.03$). Seven of the 13 patients had completed 12 months of follow-up at the time of analysis, also demonstrating a mean decrease in DASH scores of 21.08 across the follow-up period up to 12 months ($p = 0.018$). This improvement was higher than the minimal clinically important difference (►Fig. 6).

In primary open reduction internal fixation (ORIF) with grafting, excluding revision from screw fixation ($n = 9$), analysis revealed an overall reduction in DASH scores which is illustrated in ►Table 2. Crucially, overall comparison

of preoperative DASH scores to completion of treatment protocol for each patient demonstrated a significant improvement in symptoms and functionality with a mean DASH score of 8.0 ($p < 0.01$; $n = 9$). This improvement in DASH score was higher than the minimal clinically important difference.

For those undergoing revision surgery, the median time since the primary procedure was 40 months, with the range being 27 months to 51 months. There was a decrease in average DASH scores of 13.7 at completion of the treatment protocol, which was not statistically significant ($p = 0.27$, $n = 4$) and lower than the minimal clinically important difference.

Ten patients, responding at the completion of treatment, reported they would have the operation again, with six being nonresponsive.

Grip Strength

Overall, a statistically significant reduction in the mean grip strength of 10.15 kg was noted in the operated wrist ($p = 0.001$; $n = 11$) compared with the contralateral wrist (►Fig. 7). In the cases of primary ORIF with plates, a reduction of 10.71 kg was noted in the operated wrist (independent t -testing, $p = 0.003$; $n = 7$). However, no significant difference was noted between operated and nonoperated wrists in revision cases ($p = 0.18$; $n = 4$).

Smoking Status

Although five patients were smokers, only three had postoperative DASH scores, which showed a mean reduction of 5.6. Ten nonsmoking patients out of the eleven had

Table 1 DASH scores of all patients attending follow-up postoperatively

	Pre-op DASH score	Post-op DASH score at 3-month interval	Post-op DASH score at 6-month interval	Post-op DASH score at 12-month interval
Median	30	22.1	7.5	2.5
Interquartile range	18.35–37.5	9.4–45.2	1.65–30.8	0–21.825

Abbreviations: DASH, disabilities of the arm, shoulder, and hand; Post-op, postoperative; Pre-op, preoperative.

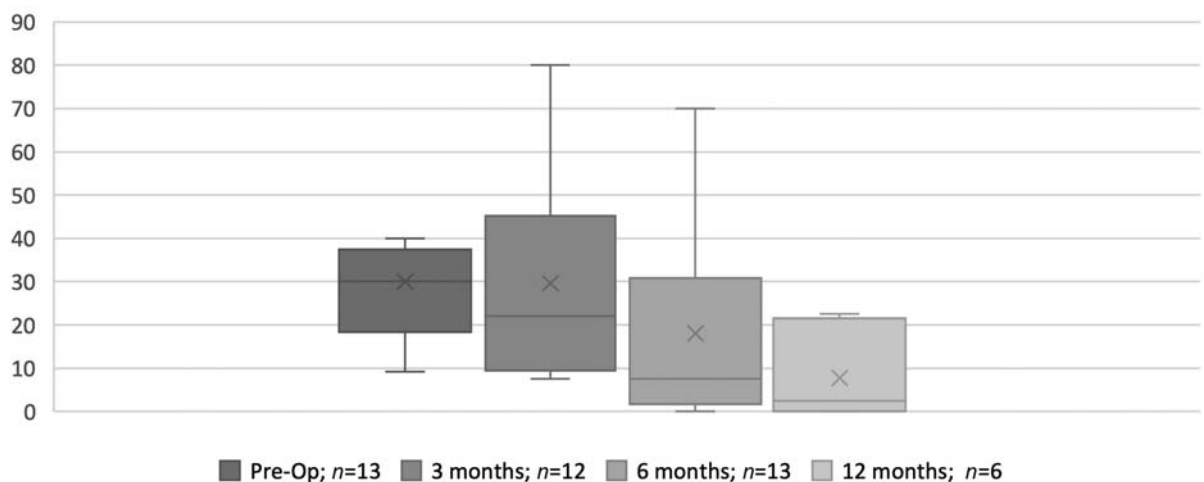


Fig. 6 DASH score comparison for all patients with follow-up data. DASH, disabilities of the arm, shoulder, and hand.

Table 2 DASH scores of primary ORIF with volar plate patients attending follow-up postoperatively

	Preoperative to 3 months	3 to 6 months	6 to 12 months	Preoperative to completion of treatment
Mean Change in DASH Score	−5.75	25.48	2.1	20.7
p-Value	0.597	0.008	0.180	0.01
Patients (n)	9	9	4	9

Abbreviations: DASH, disabilities of the arm, shoulder, and hand; ORIF, open reduction internal fixation.

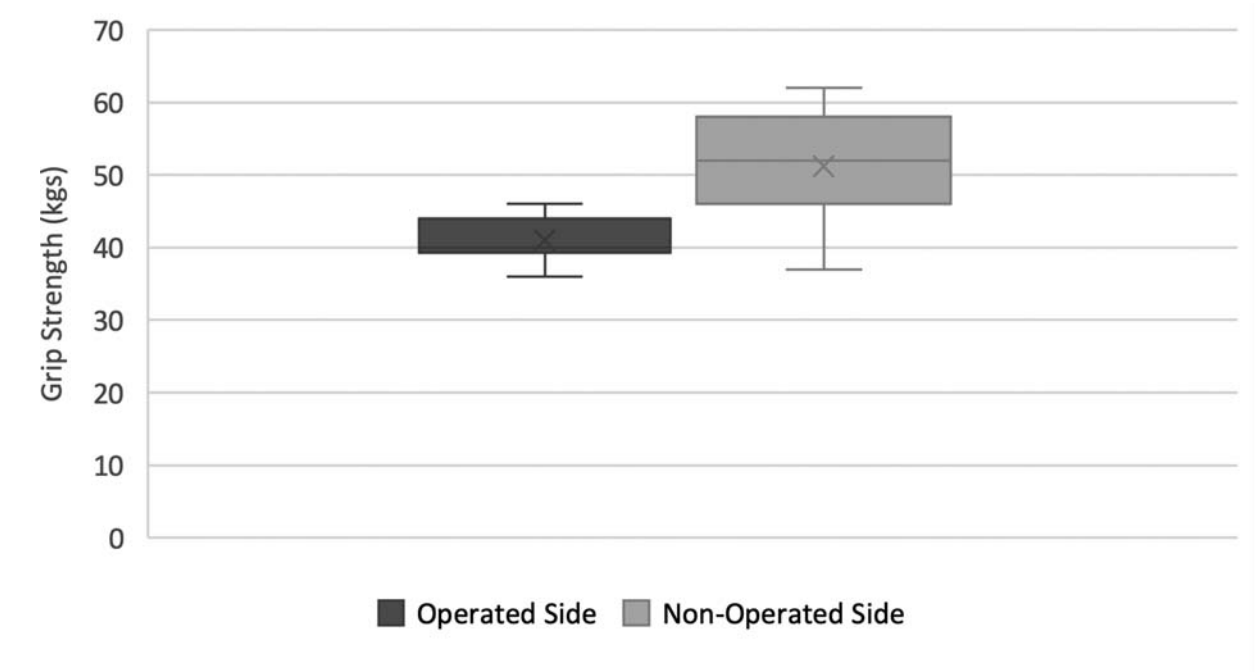


Fig. 7 Comparison of grip strength.

postoperative DASH scores, exhibiting a mean reduction in DASH scores of 19.8. This difference was not found to be significant on Wilcoxon’s testing between groups ($p = 0.592$) but is above the minimal clinically important difference.

Duration to Surgery

The mean reduction of DASH score for the group with surgery within 12 months ($n = 7$) was lower (11.1), compared with the group with surgery 12 months ($n = 6$) after primary injury (22.8). Analysis of variance testing was insignificant ($p = 0.488$), implying the end point of each group to be similar.

Complications Rate and Occupation

Out of the 16 patients, one patient had broken screws, revealing partial union on CT scan. Other complications included one developing a sensitive scar which completely resolved and another patient developing a hypertrophic scar. The patient who had the broken screws within 6 weeks of his operation had returned to work as a painter and decorator within days of his operation against advice. He is undergoing follow-up. Although it was originally anticipated that he

would require revision fixation; however, his latest CT scan has revealed that his distal scaphoid has united with the bone graft surface and the proximal fragment has bridging across this. No other complications were reported. Postoperatively, all patients reported returning to the same work.

Imaging

Plain X-ray films showed union in nine patients, with the other four patients requiring CT scan to demonstrate healing and union. Preoperative X-rays are seen in ►Figs. 8 and 9. Postoperative X-rays are shown in ►Figs. 10 and 11.

Discussion

Scaphoid nonunions are considered to be a challenging situation for both the patient and the surgeon. Patients often report wrist pain and reduced function following scaphoid nonunion.

Plate fixation for scaphoid fracture is not a novel technique. Described in 1991, the Ender plate was suggested for use in complex cases unsuitable for screw compression.¹⁹ Further studies are summarized in ►Table 3, demonstrating



Fig. 8 Lateral view prefixation.

satisfactory outcomes of plate fixation of scaphoid nonunions, reaffirming the findings of our case series.

A review completed in 2019 of current literature, supports the usage and described similar successes with plate fixation.¹⁸ Our study was conducted to not only reassert previous findings on unions, but to also observe other variables such as DASH scoring, grip strengths, impact of smoking status, impact of number of days to surgery, and complication rate.

All the patients attending follow-up clinic ($n = 13$) had achieved union by plate fixation at the time of writing, with an accompanying median DASH score of 2.5 postoperatively at 12 months ($n = 7$). Considering both the significance of



Fig. 9 PA view prefixation. PA, posteroanterior.



Fig. 10 Lateral view postfixation.



Fig. 11 PA view postfixation. PA, posteroanterior.

this data and the minimal clinically important difference, this reduction implies excellent postoperative functional outcomes. Although the patients with revision surgery following a compression screw did not achieve statistically significant improved outcomes with relation to DASH scores, it may be under powered due to low patient numbers ($n = 4$) in that subgroup of patients. Also, the overall reduction in DASH score of 13.4 in this subgroup, it is still a reliable measure of improvement using MDC₉₅ of 13 points, as stipulated in the official guidelines of using the DASH score as a reasonable proxy of the minimal clinically important difference.¹² Although the grip strength was noted to be reduced in the operated limb, assessment was performed early in the postoperative period, at an average follow-up measuring time of 4 months and hand dominance was not taken into account in our study. The complication rate was minimal and comparable to other studies conducted in the same field. All patients continued with their preinjury occupation. Interestingly, neither smoking nor time to surgery, proved to be a significant detriment to fracture healing in our study. Although, we do recognize that the sample was small, and the results may be underpowered, other studies have also used similar numbers. However, we have captured and included more data in comparison to other studies in the development of this novel technique.

For the patient and surgeon, a failure to achieve union is demoralizing. For this group of patients who are often young, this can have significant bearings on their occupation and lifestyle. The modified Matti-Russe technique described in the literature may be seen as an alternative to the locking plate system.^{27,28} However, its shortcomings in patient of older age, previous failed surgery, proximal fracture line, and long immobilization times postoperatively, limit its widespread usage.^{27,28} Recently, the usage of two headless compression screws has been advocated in the literature due to its similar rotational stability when compared with plate system and higher union rate than single-screw fixation.^{29,30} We value this approach and recommend a randomized controlled trial be conducted to compare union rates and postoperative functional outcomes of each approach.

Table 3 Previous case reports/series highlighting the advancement of the plate system for scaphoid fracture fixation

Study	Number of patients	Type of plate	Fracture type	Results
Leixnering et al ²⁰	11	Medartis 6-hole miniplate nonlocking	Nonunion waist	100% union (median, 4 months)
Mirrer et al ⁹	1	Medartis TriLock 1.5 mm 6-hole scaphoid plate	Nonunion waist	100% union (at 3 months)
Dodds et al ²¹	20	Medartis volar scaphoid plate	Nonunions with hump-back deformity	90% union (at 3 months)
Schormans et al ²²	21	Medartis APTUS Hand	Nonunion	90.47% union (at 12 months)
Burgos et al ²³	8	Medartis APTUS Hand	Nonunion waist	100% union
Putnam et al ²⁴	13	Volar locking plate	AVN of proximal pole/waist	100% union (median 4.5 months)
Quadlbauer et al ²⁵	20	Volar locking plate	Nonunion waist	85% union (with extracorporeal shockwave therapy)
Mehling et al ²⁶	20	Locking plate	Nonunion, delayed union and multifragmentary	90% union

Abbreviation: AVN, avascular necrosis.

Conclusion

Considering our positive experience coupled with other recent case series, we endorse the use of anatomical volar plates for the fixation of nonunions with a humpback deformity and for revision fixation cases. We recognize the importance of further studies and trials to clearly define the outcomes of plate fixation in patients following failed primary fixation.

Ethical Approval

East Lancashire Hospitals National Health Service Trust does not require ethical approval for reporting individual cases or case series.

Authors' contributions

F. Y. conceived the study, populated patient data and directed the study. J. K. and S. A. A. researched literature and performed data analysis. S. A. A. and J. K. wrote the first draft of the manuscript. All authors reviewed and edited the manuscript and approved the final version of the manuscript.

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None.

Conflict of Interests

None declared.

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